Open Access

J. Glob. Innov. Agric. Sci., 2024, 12(1):215-225
ISSN (Online): 2788-4546; ISSN (Print):2788-4538
DOI: https://doi.org/10.22194/JGIAS/12.1148
http://www.jgiass.com

Effect of Irrigation Cuttings at Different Growth Stages and Spraying with *Citrullus Colocynthis* Extract on the Leaf Water Balance of two Cultivars of *Zea Mays* L.

Tamara Sabah Hadi[1]*, Wisam Malik Dawood[2] and Mohammed Ali Abood[2]

[1]Ministry of Education, General Directorate of Education, Diyala, Iraq; [1,2]Department of Biology, Education College for Pure Sciences, Diyala University, Iraq.
Corresponding author's e-mail: nodi05055@gmail.com

A study in the real world with a Randomised Complete Block Design (R.C.B.D.) utilising a split-split diagrams layout with three separate replicates was carried out at the research facility of the college's water resources and soil sciences department at the Agriculture faculty / University of Diyala in the autumn season 2022. The experiment included three stages of cutting off irrigation: male flowering, milky stage, and three concentration levels of Citrullus Colocoynthis extract. Two cultivars of Zea mays L. were used: AGN720 and JAMESON. The concentration levels were 50 ml L-1 and 100 ml L-1, respectively, and two cultivars were used: AGN720 and JAMESON Citrullus Colocoynthis extract has an anti-transpiration effect on the water balance of leaves and water use efficacy of Zea mays L. grown under water stress conditions. The most important results are as follows: the AGN720 variety recorded the best water use efficiency, with an increase of 9.04% compared to the JAMESON variety. Spraying the extract of Citrullus Colocoynthis as anti-transpiration at a concentrate level of 100 ml L-1 increased the capability of water retention, relative water content, and water use efficiency. The irrigation cut-off treatment in the milky phase stage had the best water use efficiency, saving 2.559 kg of grain m-3 water compared to the no-cut irrigation treatment.
Keywords: Irrigation cut, Anti-transpiration, Citrullus colocynthis extract, Maize, Water-Retention Ability, Relative Water Content.

INTRODUCTION

Drought illustrates one of the greatest biological stress is restricting plant development significantly Biological stress is restricting plant development significantly and efficiency worldwide (Michaletti *et al.,* 2018). With rising global temperatures and variable rainfall, the proportion of area impacted by droughts is growing globally. Plants respond to water stress by increasing water intake capacity, changing cell wall flexibility, accumulating abscisic acid, or ABA, in guard cells, and closing the stomata system to control transpiration, which is which influences carbon dioxide absorption (Saha *et al.,* 2016).
Leaf water-retention capacity (WRC) constitutes criteria to guarantee water equilibrium in plants, representing the capacity of retention of protoplasm's water against desiccation (Gardner *et al.,* 2017 ; Khanh. *et al.,* 2008). Water uptake capacity (WUC) is another term for the ability for plants to utilise the most water per unit dry weight (Sangakkkara *et al.,* 1996). Higher WUC levels indicate that a plant is under more perspiration stress and will require more water to attain a saturation weight (Sangakkara *et al.,* 1996). The relative satisfaction deficits (WSD) is a phenomena which appears as one of the initial signs of a plant's reaction to different outside conditions, like salinity in the soil., drought, floods, and temperature above or below optimum limits (Grudkowska and Zagdaska, 2010). (Farouk *et al.,* 2018) discovered that as drought stress rised, so did maize plants' water saturation deficit, with the rise being more pronounced when the drought was severe.
Relative water content (RWC) is a computing of plant water status, which depicts the metabolism of tissues and is used as an indicator of drought tolerance (Rajasekar *et al.,* 2020 ; Pouresmael *et al.,* 2013) showed that RWC is one of the most important physiological traits that must be studied when evaluating drought tolerance. Plants under stress have a dangerously low relative water content and low transpiration rates, which causes a rise in vegetation temperature (Kutlu *et al.,* 2009).
Water Use Efficiency (WUE) at the whole plants level is expressed as the ratio between dry matters produced and water utilized per unit area (Monclus *et al.,* 2006). Drought-

Hadi, T.S., W.M. Dawood and M.A. Abood. 2024. Effect of Irrigation Cuttings at Different Growth Stages and Spraying with *Citrullus Colocynthis* Extract on the Leaf Water Balance of two Cultivars of *Zea Mays* L. Journal of Global Innovations in Agricultural Sciences 12:215-225.
[Received 8 May 2023; Accepted 28 Aug 2023; Published 16 Mar 2024]
Attribution 4.0 International (CC BY 4.0)

tolerant genotypes consume less water than hypersensitive genotypes (Lambers *et al.,* 2008). Water consumption is associated with shutting the stomata off, leading to decreased perspiration (Du *et al.,* 2020 ; Khalid *et al.,* 2019), hence decreased transpiration as a result of closing the stomata is the primary driver for improving water use efficient in resistant to drought cultivars (Sharma *et al.*, 2020).

According to (Halli *et al.,* 2021), Maize (Zea mays L.) represents the world's largest yielding cereal crop, yet it is particularly susceptible to changes in water stress and irrigation scheduling throughout critical periods of development, limiting grain production. Obtaining the best balance of maize yield and water utilize efficient is a significant difficulty for irrigated maize production in arid and semi-arid locations, such as Iraq, which suffers from a lack of rainfall, paucity of water resources, and high temperature. This equilibrium can be reached by spraying anti-transpiration agents and cultivating cultivars that are more resistant to dryness. Spraying anti-transpiration agents on plant leaves minimizes the transpiration rate from stomata on plants, conserves irrigation water, and minimizes the spread of diseases and insect pests, resulting in rised food production by achieving higher potential yield during drought (Morsy and Mehanna, 2022). Anti-transpiration chemicals minimize drought stress and water, trap more water in the leaves, improve photosynthetic rate, Water Use Efficiency (WUE) and chlorophyll content in plants of maize (Guleria and Shweta, 2020).

Nowadays, farmers and researchers are paying great attention to plant extracts as natural anti-transpirants for being environmentally friendly and effective in plant growth, to improve agricultural sustainability especially crop quality and quantity. Citrullus colocynthis produces many active plant secondary metabolites, including alkaloids, flavonoids (Salama *et al.,* 2017), saponins, tannins, glycosides and essential oils , Many functional secondary metabolites found in plants carry out critical and fundamental physiological and chemical functions that ensure plant vitality and longevity, particularly in terms of interactions with the surrounding atmosphere and dealing with various biotic and abiotic challenges. Flavonoids are non-enzymatic antioxidants that help plants tolerate drought stress. Another function is to rise plant drought adaption by modulating stomata mobility. They also play an important role in signal transduction, the expression of genes regulation, and maintaining the integrity of building systems activities. the processes of photosynthesis hence boosting plant performance under extreme drought circumstances (Shomali *et al.,* 2022).

Based on this point, the current research sheds light on replacing the synthetic anti-transpiration agents used with natural anti-transpiration agents in order to improve crop production under stress conditions of water. Hence, this research aims to use the method of cutting irrigation in different stages of growth to minimize the amount of water required for crop growth without causing significant effects on the yield, and to study the effect of spraying with natural extract (citrullus colocynthis extract) on the water equilibrium of the leaves of *Zea mays* L. plants, and also aims to determine the best varieties of *Zea mays* L. tolerant to irrigation cuttings at various steps of growth, and a study of the effect of interaction between irrigation cuttings and spraying with citrullus colocynthis extract on the water balance of the leaves.

MATERIALS AND WORKING METHODS

***Properties of physo-chemical of the soil*:** Before planting, the parameters of the chemical and the physical of the field soil were assessed using typical samples obtained from the soil at a depth of 0.00-0.30m.

***Preparation of Citrullus colocynthis extract*:** The fruits of Citrullus colocynthis were brought from Al-Qaim district / Al-Anbar governorate. The fruits were washed, cut and placed in a 20-liter container, then distilled water was added and the container was closed for 72 hours. It was crushed with an electric mixer, then filtered with a piece of cloth, and the extract was kept in 5-liter plastic containers until use. Two concentrate levels, 100 mL L-1 and 50 mL L-1, were prepared.

***Plant growth conditions and irrigation cut treatments*:** The experimental setup carried out on area of the land of 252 square metres, divided into three sectors, with a one-meter distance between each sector, and the number of experiment units in each sector was 18, with a total of 54 experimental units, and the area of the unit of the experiment was 26 m, with 9 lines of length 6 m, with a 70 cm distance between lines and 20 cm between rows, and a plant density of 71428 hectare-1 plants. To prevent irrigation water loss, 1 m separations were left between the main treatments and the replications. The experiment included three stages of irrigation cut-off: non-cut irrigation, cut-off of irrigation in the male flowering stage, and cut-off of irrigation in the milky stage, and three concentrate levels of Citrullus Colocynthis extract as an anti-transpiration, which included spraying the extract with two concentrate levels of 100 ml. L-1 and 50 ml. L-1, as well as the comparison treatment (spraying with water), two cultivars of maize were used, AGN720 and JAMESON, the cultivars occupied the main plots and the anti-transpiration concentrate levels the sub plots while they occupied the irrigation cutting stages the sub sub plots. Irrigation was done when 50% of the available water was drained, a drip irrigation system was used, and three irrigation treatments were used.

Full irrigation throughout the experiment period when 50% of the available water was depleted, and the amount of water added during one irrigation was 600 liters, and during the season 2550 m3 hectare-1. As for cutting irrigation in the male flowering stage: four consecutive irrigations were cut in

the male flowering stage on 3/5, 5/6, 5/9, and 5/12. As for irrigation cutting in the milky phase: four consecutive irrigations were cut in the milky phase on 6/8, 6/11, 6/14, and 6/17. The water amountadded was computed according to the relationship of Kovda et al. (1973).

$$W = a.As\left(\frac{\%Pw^{Fc} - \%Pw^{w}}{100}\right) \times \frac{D}{100} \ldots\ldots (4)$$

Since: W = the amount of water that will be added throughout irrigated (m³); a = area that irrigated (m²); As = density of the bulk (mcg m³); Pw^{Fc} = Soil percentage of moisture determined by weights (after irrigation) at the field's capacity; Pw^{w} = moisture of the soil Percentage before irrigation; D = soil depth at the required root system (cm)

***Studied Properties*:** Measurements were taken in the male flowering stage for the non-irrigation treatments, while the measurements were taken for the two irrigation cuttings in the male flowering stage and the milky stage irrigation cuttings after cutting the fourth watering for each treatment. This was done by taking a leaf from the plant according to its fresh weight. Then, it was placed in a container containing water for 24 hours, after that it was taken out and dried with a cloth and its turgid weight was taken. Finally, it was placed in the electric oven at 65 degrees Celsius for a period of 24 hours and its dry weight was recorded. The following water balance properties were estimated:

***1- Water Retention Capacity (WRC)*:** According to what was stated in Saneoka *et al*. (1995), water Retention Capacity (WRC) was computed from the following equation:

$$\mathrm{WRC} = \frac{\text{Turgid weight}}{\text{Dry weight}}$$

***2- Water Uptake Capacity (WUC)*:** This parameter can be computed utilizing what was stated in Saneoka *et al*. (1995) from the following equation:

$$\mathrm{WUC} = \frac{\text{Turgid weight } - \text{Fresh weight}}{\text{Dry weight}}$$

***3- Relative Water Content % (RWC)*:** According to what was stated in Heidary et al. (1995), this parameter can be computed from the following equation:

$$\mathrm{RWC} = \frac{\text{Fresh weight } - \text{Dry weight}}{\text{Turgid weight } - \text{Dry weight}} \times 100$$

***4- Water Saturation Deficit (WSD)*:** This parameter was calculated based on the equation of what was stated in Saneoka *et al*. (1995) from the following equation:

$$\mathrm{WSD} = 100 - \mathrm{RWC}$$

***5- Water Use Efficiency (WUE)*:** This parameter was computed based on what was stated in Howell (2001) from the following equation:

$$\mathrm{WUE} = \frac{\mathrm{GY}}{\mathrm{Wt}}$$

As: GY = grain yield (kg ha^{-1}), Wt = quantity of irrigation water added (m³ ha^{-1})

RESULTS AND DISCUSSION

***The ability of water retention*:** The analytic of variance's results shown in Table 7 which illustrate the significant differences between the averages of this property for the two studied cultivars. Moreover, results of Table 2 showed the superiority of the AGN720 variety by giving it the higher mean for the trait amounted to 4.509, an rise of 5.17% with comparing to the JAMESON variety, which reported the lower average for the trait and reached to 4.287. This is due to the genetic variation of the two cultivars, as the low ability of water retention in the JAMESON cultivar indicates a greater damage to the cell structure due to water stress compared to the AGN720 cultivar, and thus is used to indicate the intolerance of the JAMESON cultivar to stress of water (Chowdhury *et al.*, 2017).

The result in Table 2 also show that spraying the plants with anti-transpiration at a concentrate levelsof 100 ml L-1, led to a significant rise in the ability of water retention in the leaves by 16.07 and 18.60%, compared to not spraying and a concentrate levelsof 50 ml L-1, which recorded the lowest averages for this trait and reached 4.203 and 4.113. They did not differ significantly between them, and this may be attributed to the improvement of the water state of plants and the reduction of osmotic potential and loss of water from cells as a result of spraying anti-transpiration, which minimized the deterioration of plant tissues and raised the ability of leaves to retain water (Martínez *et al.*, 2007).

It is clear from the results of the same table the significant rise in the average ability to retain water in the leaves for the irrigation cut treatments. Each of the irrigation cut plants in the male flowering stage, and the irrigation cut in the milky stage gave the two highest averages of The capability of the plant's leaves to hold water and reached 4.293 and 5.183 with an rise rate 15.48 and 39.42%, respectively, compared to the treatment of non-irrigation, which recorded the lowest mean for this property, amounting to 3.718. This may be due to the fact that the loss of water loss raises the content of osmotic active substances as sugar and the amino acid proline, which have the ability to create a high hydrostatic pressure, and increasing the amount of water in cells and their ability to retain water (Khanh and Bang, 2008).

***Water Uptake Capacity in the leaves*:** The results presented in Table 3 show that spraying the plants with anti-transpiration at two of concentrate levels 50 and 100 ml L-1 lead to a significant minimize in the water uptake capacity in the leaves by 145.15% and 22.30%, compared to not spraying, which recorded the highest mean for this property, amounting to 0.725. This is due to the fact that the anti-transpiration worked on improving the water condition of plants and reducing the accumulation of dissolved substances with low molecular weight inside the cells, as proline and soluble sugars, additionally thus reducing the capability of the leaves to water absorption.

Results of the same table illustrated that there was a significant rise in the average ability to absorb water in the leaves in the irrigation cutting treatments, as each of the irrigation cutting plants in the male flowering stage and the irrigation cutting in the milky stage gave the two highest averages of the ability to absorb water in the leaves, which reached 0.752 and 0.775. No significant differences were recorded between them, with an rise rate of 68.28% and 73.49%, respectively, with comparing to the non-irrigation treatment, which recorded the lowest average for this property, amounting to 0.447. The rise in absorbing water in the male flowering stage and the irrigation cutting in the milky stage can be related to the accumulation of low-molecular-weight soluble substances inside the cells such as proline and soluble sugars, Because the cells' buildup of small-molecular-weight molecules keeps the swelling pressure in check, regular intracellular metabolic processes can continue even when the water level is low (Bodner *et al.,* 2015), as plants adapt to water stress by increasing the capacity to absorb water (Jaleel *et al.,* 2008).

***Relative Water Content*:** The analysis of variance Table 7 and Table 4 illustrated significant difference between the averages of this trait for the two cultivated varieties. Results ensured that the best values of relative water content were obtained from the AGN720 variety, as this variety recorded the highest average and reached 79.178%, an rise of 1.21% compared to the JAMESON variety, which recorded the lowest mean for this trait that was 78.229%. It should be noted here that the relative water content can indicates of drought tolerance, as it considers as one of the common physiological properties that must be studied when evaluating drought tolerance (Pouresmael *et al.,* 2013), so the AGN720 variety could be considered more drought tolerant than the JAMESON variety. Moreover, analysis of variance in Table 7 and Table 4 showed that there is a significant rise in the averages of relative content of water as a result of spraying *Zea mays* L. plants with anti-transpiration. The two spraying treatments with concentrate levels of 50 and 100 ml L^{-1} recorded the highest averages of relative water content, which are 81.285 and 82.790% respectively. This came with an rise rate of 12.84 and 14.93% compared to not spraying, which gave the lowest average relative content of water, which amounted to 72.035%. The reason for this rise when spraying anti-transpiration may be attributed to the reduction in the stomata number, and then the minimize in the rates of transpiration in the plant, and by reducing the transpiration rate , the water content rises in the leaves, thus raising the plant's capability to water's retain (Cantorea *et al.,* 2009). The Citrullus colocynthis extracts also contain an appropriate amount of potassium (465 mg 100 gm^{-1}) (Hussain *et al.,* 2014) which has an essential role in maintaining the water balance of plants under conditions of low soil water availability (Wang *et al.,* 2013). This rised the level of phenols in the cell wall, and thus riased the hydrophobic properties of the cell wall (Pervez *et al.,* 2017) .This resulted in a decrease in the transfer of water from the inside of the cell to the stomata, accordingly decreasing the transpiration rate and then increasing the relative water content (Hura *et al.,* 2013).

Results presented in the analysis of variance table (Table 7) show that there are significant differences between the means of the relative water content of leaves in maize plants as a result of cutting irrigation. The results of Table 4 show that the best relative water content in the leaves was obtained as a result of not cutting irrigation. This treatment recorded the highest average of 83.680%, with a rise of 15.69 and 4.47%, compared to the two treatments of irrigation cuttings in the male flowering stage and the milky stage, which recorded the lowest averages for this property and amounted to 72.328 and 80.102%, respectively. The rise in the relative water content as a result of not stopping irrigation can be related to the high moisture content of the soil and the availability of water around the root zone in sufficient quantity. This makes it easier for the plant to absorb its water needs. The lower of the relative water content in the male flowering stage and the milky stage is resulted by the lower in the soil water potential which led to a reducing in the ability of the plant to absorb water and then a decrease in the relative water content in the tissues (Zare *et al.,* 2014), as well as a balancing between water absorption and transpiration, which negatively affected the water content of the tissues. This is consistent with Anjorin et al. (2016) who documented a lower relative water content of leaves in maize plants exposed to water stress.

Table 1. Illustrates the most essential chemical and physical properties of soil before planting

Property	Value	Unit of measure
Sand	24	g kg^{-1}
Silt	624	g kg^{-1}
Clay	352	g kg^{-1}
Soil texture	loamy, silty mixture	-
The bulk density	1.47	megagrams M^{-3}
The true density	2.65	megagrams M^{-3}
Total porosity	0.445	%
Moisture content of volumetric at 33 kPa Volumetric moisture content at33 kPa	0.291	cm^3 cm^{-3}
Moisture content of volumetric at 1500 kPa	0.184	cm^3 cm^{-3}
Ready water	0.107	cm^3 cm^{-3}
Soil salinity EC1	6.20	(m^{-1} deciSiemens)
Ph	7.59	-
Organic matter	1.22	%
Ready phosphorus	7.34	mg kg^{-1}
Total nitrogen	1.79	%
CEC exchange capacity of positive ions	17.74	centimoles of charge kg^{-1}

Table 2. The effect of cultivars, spraying with Citrullus colocynthis extract, and irrigation cutting at different stages of growth and the interaction between them on the ability to bind water

Variety× anti-transpiration concentrate level	Irrigation cutting stage			anti-transpiration concentrate level	Variety
	The milky stage	The male flowering stage	without cutting		
4.333	4.750	4.000	4.250	Spraying with water	AGN720
4.193	5.250	4.000	3.330	50ml-L1	
5.000	6.000	5.000	4.000	100ml-L1	
4.072	4.250	3.900	4.067	Spraying with water	JAMESON
4.033	5.100	4.000	3.000	50ml-L1	
4.757	5.750	4.860	3.660	100ml-L1	
n.s		n.s		L.S.D.0.05 triple overlap	
4.509	5.333	4.333	3.860	AGN720	Variety × irrigation cutting
4.287	5.033	4.253	3.576	JAMESON	
0.084		n.s		L. S. D 0.05 for Overlap between varieties and irrigation cutting	
4.203	4.500	3.950	4.158	Spraying with water	anti-transpiration× irrigation cutting
4.113	5.175	4.000	3.165	50ml-L1	
4.878	5.875	4.930	3.830	100ml-L1	
0.148		0.219		L.S.D 0.05 for overlap between the concentrate levels of the anti-transpiration and irrigation cutting	
	5.183	4.293	3.718	Average of water irrigation cutting	
		0.126		L.S.D 0.05 for cutting irrigation water	

Table 3. The effect of cultivars, spraying with Citrullus colocynthis extract, and irrigation cutting at different stages of growth and the interaction between them on the water uptake ability

Variety × anti-transpiration concentrate level	Irrigation cutting stage			Anti-transpiration concentrate level	Variety
	The milky stage	The male flowering stage	Without cutting		
0.917	1.000	1.000	0.750	Spraying with water	AGN720
0.387	0.500	0.330	0.330	50ml-L1	
0.693	0.750	1.000	0.330	100ml-L1	
0.857	1.000	0.920	0.650	Spraying with water	JAMESON
0.337	0.400	0.310	0.300	50ml-L1	
0.757	1.000	0.950	0.320	100ml-L1	
n.s		n.s		L.S.D.0.05 triple overlap	
4.509	5.333	4.333	3.860	AGN720	Variety × irrigation cutting
4.287	5.033	4.253	3.576	JAMESON	
n.s.		n.s.		L.S.D 0.05 for Overlap between varieties and irrigation cutting	
0.887	0.960	1.000	0.700	Spraying with water	anti-transpiration × irrigation cutting
0.362	0.450	0.320	0.315	50ml-L1	
0.725	0.875	0.975	0.325	100ml-L1	
0.069		0.106		L.S.D 0.05 for overlap between the concentrate levels of the anti-transpiration and irrigation cutting	
	0.775	0.752	0.447	Average of water irrigation cutting	
		0.062		L.S.D 0.05 for cutting irrigation water	

Table 4. The effect of cultivars, spraying with Citrullus colocynthis extract, and irrigation cuts at different stages of growth and the interaction between them on the relative water content (%).

Variety × anti-transpiration concentrate level	Irrigation cutting stage			anti-transpiration concentrate level	Variety
	The milky stage	The male flowering stage	Without cutting		
72.303	73.330	66.660	76.920	Spraying with water	AGN720
82.270	83.330	77.770	85.710	50ml-L1	
82.960	85.000	75.000	88.880	100ml-L1	
71.767	72.850	65.810	76.640	Spraying with water	JAMESON
80.300	80.900	73.100	86.900	50ml-L1	
82.620	85.200	75.630	87.030	100ml-L1	
0.061		0.106		L.S.D.0.05 triple overlap	
79.178	80.553	73.143	83.837	AGN720	Variety × irrigation cutting
78.229	79.650	71.513	83.523	JAMESON	
0.101		0.051		L.S.D 0.05 for Overlap between varieties and irrigation cutting	
72.035	73.090	66.235	76.780	Spraying with water	anti-transpiration× irrigation cutting
81.285	82.115	75.435	86.305	50ml-L1	
82.790	85.100	75.315	87.955	100ml-L1	
0.036		0.075		L.S.D 0.05 for overlap between the concentrate levels of the anti-transpiration and irrigation cutting	
	80.102	72.328	83.680	Average of water irrigation cutting	
		0.043		L.S.D 0.05 for cutting irrigation water	

Table 5. The effect of cultivars, spraying with Citrullus colocynthis extract, and cutting irrigation at different stages of growth and the interaction between them on the water saturation deficit (%)

Variety× anti-transpiration concentrate level	Irrigation cutting stage			anti-transpiration concentrate level	Variety
	The milky stage	The male flowering stage	Without cutting		
27.697	26.670	33.340	23.080	Spraying with water	AGN720
17.730	16.670	22.230	14.290	50ml-L1	
17.040	15.000	25.000	11.120	100ml-L1	
26.273	25.900	30.670	22.250	Spraying with water	JAMESON
16.773	15.570	20.850	13.900	50ml-L1	
16.477	14.330	24.000	11.100	100ml-L1	
0.078		0.119		L.S.D.0.05 triple overlap	
20.822	19.447	26.857	16.163	AGN720	Variety × irrigation cutting
19.841	18.600	25.173	15.750	JAMESON	
0.078		0.068		L.S.D 0.05 for Overlap between varieties and irrigation cutting	
26.985	26.285	32.005	22.665	Spraying with water	anti-transpiration× irrigation cutting
17.252	16.120	21.540	14.095	50ml-L1	
16.758	14.665	24.500	11.110	100ml-L1	
0.055		0.084		L.S.D 0.05 for overlap between the concentrate levels of the anti-transpiration and irrigation cutting	
	19.023	26.015	15.957	Average of water irrigation cutting	
		0.048		L.S.D 0.05 for cutting irrigation water	

Table 6. The effect of cultivars, spraying with bitter hibiscus extract, and irrigation cuts at different stages of growth and the interaction between them on the average water use efficiency of grain yield (kg grains m3 water)

Variety × anti-transpiration concentrate level	Irrigation cutting stage			anti-transpiration concentrate level	Variety
	The milky stage	The male flowering stage	Without cutting		
2.047	2.233	1.740	2.167	Spraying with water	AGN720
2.431	2.680	1.963	2.650	50ml-L1	
2.692	3.003	2.247	2.827	100ml-L1	
1.946	2.183	1.633	2.020	Spraying with water	JAMESON
2.213	2.473	1.820	2.347	50ml-L1	
2.417	2.780	1.960	2.510	100ml-L1	
0.066		n.s.		L.S.D.0.05 triple overlap	
2.390	2.639	1.983	2.548	AGN720	Variety × irrigation cutting
2.192	2.479	1.804	2.292	JAMESON	
0.055		n.s		L.S.D 0.05 for Overlap between varieties and irrigation cutting	
1.996	2.208	1.687	2.093	Spraying with water	anti-transpiration× irrigation cutting
2.322	2.577	1.892	2.498	50ml-L1	
2.554	2.892	2.103	2.668	100ml-L1	
0.043		0.075		L.S.D 0.05 for overlap between the concentrate levels of the anti-transpiration and irrigation cutting	
	2.559	1.894	2.420	Average of water irrigation cutting	
		0.043		L.S.D 0.05 for cutting irrigation water	

Table 7. Analysis of variance for the properties studied

Sources of variation	Water efficiency	Relative water content	Water use efficiency	Water retention capacity	Water uptake capacity	Degree of freedom
Replications	0.013	0.022	2358.462	0.049	0.015	2
Varieties	0.530^{**}	12.155^{**}	10.818	0.662^{**}	$0.003^{n.s.}$	1
Error (A)	0.003	0.010	0.106	0.007	0.006	2
Anti- transpiration concentrate levels	1.416^{**}	610.500^{**}	337.803	3.149^{**}	1.301^{**}	2
Variety *anti	0.036^{*}	3.563^{**}	0.449	$0.013^{n.s}$	$0.021^{n.s}$	2
Error (B)	0.005	0.003	24.398	0.050	0.011	8
Irrigation cutting stages	2.215^{**}	606.200^{**}	238.622	9.814^{**}	0.604^{**}	2
Varietis * cutting stages	$0.012^{n.s}$	1.957^{**}	0.824	$0.068^{n.s}$	$0.015^{n.s}$	2
Anti* cutting stages	0.035^{**}	4.769^{**}	4.062	1.526^{**}	0.163^{**}	4
Varieties*anti*cutting	$0.003^{n.s}$	6.959^{**}	0.095	$0.027^{n.s}$	$0.016^{n.s}$	4
Error (C)	0.004	0.004	10.392	0.034	0.008	24

** = highly significant at the 0.01 n.s level * = significant at the 0.05 n.s level = not significant

Analysis of variance in Table 7 and the results shown in Table 4 illustrates that there are significant differences between the averages of this trait, which were obtained as a result of the triple overlap between each of the cultivars, anti-transpiration concentrate levels, and irrigation cut-off stages. The combination of non-irrigation + cultivar AGN720 + concentrate levels of Anti-transpiration 100 ml L-1 recorded the highest average and reached 88.880%, while the combination of irrigation cuttings at the stage of male flowering + JAMESON + without antiperspirant recorded the lowest average and amounted to 65.810%. This is due to the positive effect of anti-transpiration, the effective and important role of water, and the response of cultivar AGN720 to the average trait compared to cultivar JAMESON due to their genetic variation

***4- Water Saturation Deficit*:** It is evident from the results contained in the analysis of variance table (Table 7) the significant difference between the averages of the varieties for this property, and the results of Table 5 indicate the superiority of the AGN720 variety by giving it the highest

average of 20.822%, with a rise of 4.94% compared to the JAMESON variety, which recorded the lowest average and amounted to 19.841%, which is attributed to This is due to the genetic differences between the two cultivars.

The results in Table 5 show that spraying the plants with anti-transpiration at two concentrate levels of 50 and 100 ml L-1, led to a significant lower in the percentage of water deficit in the leaves by 36.07 and 37.90% compared to not spraying, which recorded the highest average and reached 26.985%, and this may be attributed to reduction of the osmotic potential and water loss from the cells as a conclusion of antifungal spraying, thus raising the plant's ability to absorb water and decreasing the water saturation deficit.

The results presented in the analysis of variance table (Table 7) show that there was a significant rise in the average percentage of water deficit in the leaves in the irrigation cutting treatments, as each of the irrigation cutting plants in the male flowering stage and the irrigation cutting in the milky stage gave the two highest averages for the percentage of water deficit in the leaves .They amounted to 26.015 and 19.023%, with an rise of 63.03% and 19.22%, respectively, compared to the non-irrigation treatment, which recorded the lowest average for this property amounting to 15.957% (Table 5). Plants in water deficit circumstances work on reducing its water potential in order to be less than soil water potential. In accordance with the continued decrease in soil water potential, the plant may not be able to continue reducing its water potential, so it is unable to absorb water, and for this reason, a rise in the percentage of water deficit is observed in each of the irrigation cutting treatments in the male flowering stage and cutting it in the milky stage. This is consistent with Gul *et al.* (2022) who found an rise in water deficit percentage of maize leaves exposed to water stress.

The results presented in the analysis of variance table (Table 7) show the significant different between the average of this trait obtained as a result of the triple overlap between cultivars, anti-transpiration concentrate levels and irrigation cut-off stages. It reached 33.340%, while the combinations consisting of JAMESON cultivar + anti-transpiration concentrate levels100 ml L-1 + non-cutting of irrigation, and cultivar AGN720 + anti-transpiration concentrate levels100 ml L-1 + non-cutting of irrigation recorded the lowest medium and amounted to 11.100 and 11.120%, respectively. No significant differences were recorded between them (Table 5).

***5- Water use efficiency of grain yield (kg grain m^3 water)*:** It is clear from the analysis of variance (Table 7) that there are significant differences at the level of probability of 5% between the averages of this trait for the two cultivated varieties, and the results in Table 6 show that the best values for water use efficiency were obtained with the AGN720 variety, as this variety recorded the highest average and amounted to 2.390 kg grain M-3 water, with an rise of 9.04% compared to the JAMESON cultivar, due to the genetic variation of the two cultivars, as well as the rise ability of the AGN720 cultivar to retain water by increasing the relative water content of the leaves (Table 4).

It is clear from the results of the analysis of variance (Table 7) and (Table 6) that there is a significant rise in the averages of water use efficiency as a result of spraying *Zea mays* L. plants with anti-transpiration. The two spraying treatments with concentrate levels of 50 and 100 ml L-1 recorded the highest averages of water use efficiency, amounting to 2.322 and 2.554 kg. M-3 tablets of water, respectively, with a rise rate of 16.57 and 28.21%, compared to not spraying with the antifungal agent, which recorded the lowest average water use efficiency, amounting to 1.992 kg of M-3 tablets of water. Anti-transpiration works to rise the plant's ability to retain water by reducing the prevalence of stomata and the transpiration rate in the plant (Cantore *et al.*, 2009).This improvement in the water state of the plant is directly reflected in the water use efficiency, especially under conditions of water stress. It leads to a significant rise in terms of absolute amount of water in the leaves by decreasing the transpiration rate and thus increasing the water use efficiency (Khalel, 2015). Besides, anti-transpiration may regulate physiological processes and improve vegetative growth, which rises the efficiency of transferring manufactured materials through the process of carbon metabolism to grains (Aba - Muriefah, 2013).

The results of variance analysis (Table 7) indicate significant differences between The mean effectiveness of water usage in plantations of maize as a result of cutting irrigation. The results of Table 6 show that the best water use efficiency was obtained as a result of cutting irrigation in the milky phase, as this treatment recorded the highest average and reached 2.559 kg of M-3 grains of water, with a rise of 5.74% and 35.11%, compared to the two treatments of no-cut irrigation and cut-irrigation of the male flowering stage, respectively. The treatment of irrigation cut-off of the male flowering stage recorded the lowest average for this property, amounting to 1.894 kg of M-3 grains of water. The rise efficient use of water for the treatment of irrigation plots in the milky phase means achieving a higher grain yield by using less water, i.e. every hundred cubic meters of irrigation water has an rise in grains of 5.74 kg, and the percentage of irrigation water saving is 11.76% compared to the non-irrigation treatment. The water use efficiency is used as an indicator of the plant's ability to exploit water resources to produce the grain crop per unit area (Karasu *et al.*, 2015),

The justification for the rise in water utilize efficiency for the treatment of irrigation plots in the milky phase may be identified to the fact that the amount of water added was close to the crop's water consumption values. As for the reason for the low water use efficiency for the treatment of irrigation cuttings during the male flowering stage, it is due to the importance of optimal humidity during the flowering stage in increasing the efficiency of water use through its effect on

increasing the activity and vitality of pollen grains and the completion of the pollination and fertilization process and the completion of ear seeds. Singh and others (2014) found that increasing water use efficiency can only come from either increasing grain yield or saving in the amount of water used. This result is consistent with the findings of *Zhao et al.* (2018) who indicated that water use efficiency could be raised by reducing irrigation water quantities.

We note from the previous results that the AGN720 variety is more drought tolerant than the JAMESON variety, due to its superiority over the second variety in the ability to retain water and the relative water content, with a rise of 5.17 and 1.21%, respectively. The AGN720 variety recorded the best values of water use efficiency with a rise of 9.04% compared to the JAMESON cultivar. Spraying the extract of Citrullus colocynthis fruits as an anti-transpiration at a concentrate levels of 100 ml L-1 minimized the effects resulting from water stress by increasing the ability to retain water, relative water content and water use efficiency with an rise of 18.60, 14.93 and 28.21%.This addition minimized the relative saturation deficit by 37.90%, and the irrigation cut-off treatment in the milky stage was characterized by the best water-use efficiency of 2.559 kg grain M-3 water, compared to the non-cut irrigation treatment that gave a water-use efficiency of 2.420 kg grain M-3 water. This led to saving the amount of 11.76% of water. Therefore, it is recommended to plant AGN720 cultivar in the study area, and spray maize plants with an extract of Citrullus colocynthis fruits to minimize water loss through transpiration and improve their ability to withstand water stress.

Conclusion**:** The purpose of this study was to find out how irrigation cuts and Citrullus colocynthis ex spraying affected plant growth. The results of this study reveal that Citrullus colocynthis ex usage can improve plant growth and yield, which has important significance for the sector of agriculture. It is crucial to recognise the study's limitations, such as the small sample size and brief experimentation period. Therefore, larger and longer-term studies are recommended for future study to better validate these findings. This study offers encouraging data for Citrullus colocynthis usage as a natural plant growth promoter. It creates fresh opportunities for farmers and agricultural experts to investigate different strategies for raising crop yields and lowering reliance on synthetic fertilisers. The study also emphasises the significance of taking traditional knowledge and indigenous practises into account in modern agriculture, as many of these practises have been around for a very long time and may include insightful information about sustainable farming methods. In general, this work supports further investigation of these options in agriculture and adds to the expanding body of knowledge about natural plant growth promoters. To increase agricultural production and sustainability, future research should concentrate on finding and utilizing additional natural plant growth promoters and conventional methods.

Authors' contributions statement: All authors as equal contributions in this work.

Conflict of interest: The authors declare no conflict of interest.

Funding: No funding

Ethical statement: This article does not contain any studies regarding humans or Animals.

Availability of data and material: We declare that the submitted manuscript is our work, which has not been published before and is not currently being considered for publication elsewhere.

Code availability: Not applicable.

Consent to participate: All authors participated in this research study.

REFERENCES

Abu-Muriefah, S. S. 2013. Effect of chitosan on common bean (Phaseolus vulgaris L.) plants grown under water stress conditions. International Research Journal of Agricultural Science and Soil Science 3:192-199. https://www.interesjournals.org/articles/effect-of-chitosan-on-common-bean-phaseolus-vulgaris-l-plants-grown-under-water-stress-conditions.pdf.

Anjorin, F.B., S.A. Adejumo, L. Agboola and Y.D. Samuel. 2016. Proline, soluble sugar, leaf starch and relative water contents of four maize varieties in response to different watering regimes. Cercetări Agronomice în Moldova 49:51-62. https://repository.uaiasi.ro/handle/20.500.12811/1182

Bodner, G, A. Nakhforoosh and H. P. Kaul. 2015. Management of crop water under drought: a review. Agronomy for Sustainable Development 35:401-442.https://doi.org/10.1007/s13593-015-0283-4

Cantore, V., B. Pace and R. Albrizio. 2009. Kaolin-based particle film technology affects tomato physiology, yield and quality. Environmental and Experimental Botany 66:279-288.https://doi.org/10.1016/j.envexpbot.2009.03.008

Chowdhury, J. A., M. A. Karim, Q. A. Khaliq, A. U. Ahmed and A. M. Mondol. 2017. Effect of drought stress on water relation traits of four soybean genotypes. SAARC Journal of Agriculture 15:163-175. DOI:10.3329/sja.v15i2.35146

Du, Y., Q. Zhao., L. Chen, Yao, X. W. Zhang, B. Zhang, F. Xie. 2020. Effect of drought stress on sugar metabolism in leaves and roots of soybean seedlings. Plant Physioly

Biochem 146:102. https://doi.org/10.3390/agronomy10020302

Farouk S, S A, Arafa and R.M.A. Nassar. 2018. Improving drought tolerance in corn (Zea mays L) by foliar application with salicylic acid. International Journal Environ 7:104-123

Gardner, F. P., R. B. Pearce and R. L. Mitchell. 2017. Physiology of crop plants (No. Ed. 2). Scientific Publishers. https://www.scientificpubonline.com

Grudkowska, M., and B. Zagdańska. 2010. Acclimation to frost alters proteolytic response of wheat seedlings to drought. Journal of plant physiology 167:1321-1327.https://doi.org/10.1016/j.jplph.2010.05.019

Gul, N, Z. U, H. Haq, F. Ali, S. S. U. Munsif, Hassan, and S. Bungau. 2022. Melatonin Pretreatment Alleviated Inhibitory Effects of Drought Stress by Enhancing Anti-Oxidant Activities and Accumulation of Higher Proline and Plant Pigments and Improving Maize Productivity. Agronomy 12:2398. https://doi.org/10.3390/agronomy12102398.

Guleria V, Shweta. 2020. Antitranspirants: an effective approach to mitigate the stress in field crops. International Journal of Current Microbiology and Applied Sciences (IJCMAS) 9:1671-1678 DOI: https://doi.org/10.20546/ijcmas.2020.905.188

Halli H. M, S. Angadi, A. Kumar, P. Govindasamy, R. Madar, D.C.V. Baskar, H.O. Elansary, N. Tamam, A.M.M. Abdelbacki and S.A.M. Abdelmohsen. 2021. Assessment of planting method and deficit irrigation impacts on physio-morphology, grain yield and water use efficiency of maize (*Zea mays* L.) on vertisols of semi-arid tropics. Plants 10:1-18. https://doi.org/10.3390/plants10061094

Heidari, A., Toorchi, M., A. Bandehagh and M. R. Shakiba. 2011. Effect of NaCl Stress on Growth, Water Relations, Organic and Inorganic Osmolytes Accumulation in Sunflower (Helianthus annuus L.) Lines. Universal Journal of Environmental Research & Technology 3:351-362 http://www.environmentaljournal.org/1-3/ujert-1-3-15.pdf

Howell, J. A. 2001. Enhancing water use efficiency in irrigated agriculture. Agronomy J.93: 281-289. https://doi.org/10.2134/agronj2001.932281x

Hura, T., K.A. Hura, M. Ostrowska, K. Grzesiak and Dziurka H.2013. The cell wall-bound phenolics as a biochemical indicatorof soil drought resistance in winter triticale. Plant Soil and Environment, 59:189-195. https://doi.org/10.17221/665/2012-PSE

Hussain, A. I., H. A. Rathore, M. Z. Sattar, S. A. Chatha, S. D. Sarker, and A. H. Gilani 2014. Citrullus colocynthis (L.) Schrad (bitter apple fruit): A review of its phytochemistry, pharmacology, traditional uses and nutritional potential. Journal of ethnopharmacology 155:54-66. https://doi.org/10.1016/j.jep.2014.06.011

Jaleel, C. A., R. Gopi, B. Sankar, M. Gomathinayagam, and R. Panneerselvam .2008. Differential responses in water use efficiency in two varieties of Catharanthus roseus under drought stress. Comptes Rendus Biologies 331:42-47.https://doi.org/10.1016/j.crvi.2007.11.003

Karasu, A., K. Hayrettin and O Mehmet. 2015 .Yield and economic return respone of Silage Maize to different levels of irrigation water in a sub_huimid zone. Zemdirbyste-Agriculture 102:313-318. DOI:10.13080/z-a.2015.102.040

Khalel , A.S. 2015. Effect of drip irrigation intervals and some Antitranspirants on the water status , Growth and yield of potato (*Solanum tuberosum* L.) . Journal of Agricultural Science and Technology 5:15-23 DOI:10.17265/2161-6264/2015.01B.002

Khalid, M.F., S. Hussain , S. Ahmad, S. Ejaz, I. Zakir, M.A. Ali, N. Ahmed, M.A. Anjum. 2019. Impacts of Abiotic Stresses on Growth and Develop- ment of Plants. In Plant Tolerance to Environmental Stress; CRC Press: Boca Raton, FL, USA, pp. 1-8. DOI:10.1201/9780203705315-1

Khanh, N. N. and C. P. Bang. 2008. Plant physiology. Educational Publishing House. 368pp. https://hal.science/hal-03040546/document

Kovda, V. A., R. M. Hagan, and C. Van.1973. Irrigation, Drainage and Salinity: An International Source Book Fao-unesco. Presses de l'Unesco., London. https://www.scirp.org

Kutlu, N., R. Terzi, Ç. Tekeli, G. Şenel, P. Battal and A. KADIOĞLU. 2009. Changes in anatomical structure and levels of endogenous phytohormones during leaf rolling in Ctenanthe setosa under drought stress. Turkish Journal of Biology 33:115-122.

Lambers, H, F.S. Chapin and T.L. Pons. 2008. Plant physiological ecology. New York, NY, USA: Springer. https://doi.org/10.1007/978-0-387-78341-3_13

Martínez, J. P, H. F. L. J. Silva, J. F. Ledent and M. Pinto .2007. Effect of drought stress on the osmotic adjustment, cell wall elasticity and cell volume of six cultivars of common beans (*Phaseolus vulgaris* L.). European journal of agronomy 26:30-38. https://doi.org/10.1016/j.eja.2006.08.003

Michaletti, A. Naghavi., M. R. Toorchi, L. M. Zolla and S. Rinalducci. 201. Metabolomics and proteomics reveal drought-stress responses of leaf tissues from spring-wheat. Scientific reports 8:5710. https://doi.org/10.1038/s41598-018-24012-y

Monclus, R, E. Dreyer, M. Villar, F.M. Delmotte, D. Delay, J.M. Petit,C. Barbaroux, D.L. Thiec , C. Breche, and F. Brignolas.2006. Impact of drought on productivity and water use efficiency in 29 genotypes of Populus deltoids x Populus nigra. New Phytology 169:765-777. https://doi.org/10.1111/j.1469-8137.2005.01630.x

Morsy, A. S. M., and H. M. Mehanna. 2022. Beneficial effects of antitranspirants on water stress tolerance in maize under different plant densities in newly reclaimed land. Bulletin of the National Research Centre 46:1-17.

Pervez, K., F. S. Ullah, A, Mehmood. and A. Khattak. 2017. Effect of Moringa oleifera Lam. leaf aqueous extract on growth attributes and cell wall bound phenolics accumulation in maize (*Zea mays* L.) under drought stress. Kuwait Journal of Science 44: https://journalskuwait.org/kjs/index.php/KJS/article/view/2015

Pouresmael, M, R. A. Khavari-Nejad, J. Mozafari, F. Najafi and F. Moradi. 2013. Efficiency of screening criteria for drought tolerance in chickpea. Archives of Agronomy and Soil Science 59:1675-1693.

Rajasekar, M., S. A. Hussainy and A. Karthik. 2020.Effect of moisture deficit conditions on the performance of maize (Zea mays): A review. International Journal of Chemical Studies 2:2603-2609.

Saha, B., G. Borovskii, and S. K. Panda. 2016. Alternative oxidase and plant stress tolerance. Plant signaling & behavior 11:e1256530. https://doi.org/10.1080/15592324.2016.1256530

Saneoka, H.,C. Nagasaka,T.D Hahn, J.W. Yang,G. S. Premachandra, J.R. Joly and D. Rhodes.1995. Salt tolerance of glycinebetaine-deficient and-containing maize lines. Plant Physiology 107:631-638.

Salama, F, A. El-Ghani, N. , El-Tayeh, A. Amro and S El-Naggar. 2017. Some aspects of drought resistance in Citrullus colocynthis L. in the Egyptian deserts. Taeckholmia 37:52-66. DOI 10.21608 / TAEC.2017.11935

Sangakkara, U. R, U. A. Hartwig and J. Nösberger.1996. Response of root branching and shoot water potentials of french beans (Phaseolus vulgaris L.) to soil moisture and fertilizer potassium. Journal of Agronomy and Crop Science 177:165-173.https://doi.org/10.1111/j.1439-037X.1996.tb00234.x

Sharma, A., J. Wang, D. Xu, S. Tao, S. Chong, D. Yan , Z. Li, H. Yuan and B. Zheng .2020. Melatonin regulates the functional components of photosynthesis, antioxidant system, gene expression, and metabolic pathways to induce drought resistance in grafted Carya cathayensis plants. Science of Total Environment, 713:136675. https://doi.org/10.1016/j.scitotenv.2020.136675

Shomali, A., S. Das, N., M. Sarraf, N. Zahra, V., Yadav and M. Hasanuzzaman.2022. Diverse Physiological Roles of Flavonoids in Plant Environmental Stress Responses and Tolerance. Plants 11:3158. https://doi.org/10.3390/plants11223158

Singh, L., M. K. A. Beg, S. Akhter, S. Qayoom B. A. Lone, P. Singh and P. Singh. 2014. Efficient techniques to increase water use efficiency under rainfed eco-systems. Journal of AgriSearch 1:193-200 . https://jsure.org.in/journal/index.php/jas/article/view/8

Wang, M, Q. Zheng, Q. Shen and S. Guo. 2013. The critical role of potassium in plant stress response. International Journal of Molecular Sciences 14:7370-7390. https://doi.org/10.3390/ijms14047370

Zare, K., F. Vazin and M. H. Zadehdelouei. 2014. Effects of potassium and iron on yield of corn Zea mays L. in drought stress . Repository of Iași University of Life Sciences, ROMANIA. Mol1:39-47. (URI): https://repository.uaiasi.ro/xmlui/handle/20.500.12811/1647

Zhao, J, Q. Xue, K. E. Jessup B. Hao, X Hou, T. H. Marek and D. K. Brauer. 2018. Yield and water use of drought-tolerant maize hybrids in a semiarid environment. Field Crops Research 216:1-9. https://doi.org/10.1016/j.fcr.2017.11.001